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A COMPARISON OF THE SHALLOW-WATER SPONGES NEAR THE PACIFIC END OF THE PANAMA CANAL WITH THOSE AT THE CARIBBEAN END

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During the summer of 1933 I made a study of the intertidal sponge fauna at each end of the Panama Canal.[1] Specimens were collected from intertidal waters or from waters barely below low tide, entirely without dredging. The method most frequently employed was wading and collecting by hand, but in some cases an ordinary garden rake was used from a rowboat.

The sponges of the deeper ocean differ radically from those in intertidal and shallow waters. This has been well brought out by various authors, particularly by Burton (1928). Seldom do sponges from one of these habitats venture over into the other. In general the sponges of the deeper waters of one ocean are related to those in other oceans from similar depths rather than to the adjacent shallow-water forms. The latter are likely to show more regional or local specializations than are sponges from greater depths. It was therefore deemed more important to compare the shallow-water sponges from the Atlantic end of the Panama Canal with those from the Pacific end than to make any effort to collect sponges from deeper waters farther out on either side of the isthmus.

[1] Thanks are due to Dr. James Zetek, of the U. S. Bureau of Entomology and Plant Quarantine, and to various other officials connected with the Government staff in the Panama Canal Zone who made it possible to carry on the collecting and locate suitable places for finding sponges, and to officials of the U. S. National Museum, especially Dr. Alexander Wetmore and Dr. Waldo L. Schmitt, for help and cooperation.

There are various reasons for believing that shallow-water sponges attain distribution laterally rather slowly, or at least that they are profoundly restrained by environmental barriers. In 1932 (de Laubenfels, 1932) I found considerable difference between the coastal sponges of central and southern California, and I can report subsequent (as yet unpublished) investigation in the field indicating even greater differences between the sponges of California and those of the coast only a few hundred miles north of that State, and similarly great differences between the sponges of California and Lower California. At the Pacific end of the Panama Canal there are tremendously high tides and at the Atlantic end almost no tides at all, whereas at the Atlantic end the ocean temperature is considerably higher than at the Pacific. A great difference between the faunas of the two regions was therefore to be expected. Such a difference might be due to the different ecological conditions or to independent evolutions during a geologically long period of separation. Similarities between the faunas of the two regions would be less easily explained. A marine connection until recent times might be assumed, although other reasons for this assumption are scanty. Perhaps throughout whole geologic ages sponge species neither vary much (in an evolutionary sense) nor perish as species, nor migrate away from their established locations.

Sixteen species of sponges were collected at or near the Pacific end of the Panama Canal, and 21 species were taken at the Atlantic end. Ten species were found only on the Pacific side and 15 only on the Atlantic, while six occurred in both localities. Of these six, only two are cosmopolitan; four are distinctive of this part of the world!

The Porifera of the Caribbean end show close relationship to the West Indian fauna. An astonishing number of them were new species, no less than seven, or 33 percent. In general the Pacific coasts of Central and South America have been exceedingly little studied, and it might be expected therefore that more new species would have been found in that region, but such was not the case. Only five species on the Pacific coast proved to be new, again a third of the number collected. Searching over the rocks exposed at low tide at Panama City yielded nine species and proved astonishingly similar to collecting near Plymouth, England. Four out of the nine—*Haliclona permollis*, *Halichondria panicea*, *Microciona atrosanguinea*, and *Oscarella lobularis*—are forms common to both localities. Of other species occurring nearby, *Toxadocia proxima* is Arctic, *Pseudosuberites sulcatus* is Antarctic, and *Aplysilla glacialis* is both Arctic and sub-Antarctic.

Attention is called particularly to the dissimilarities between the Panama sponge fauna and that of the Pacific coast of North America in general. Of the sponges recorded from California, at least 11 per-

cent are also recorded from Puget Sound, 1,200 kilometers north, but this latter area has been less intensively studied; of a collection I made in that region in the summer of 1931, 62 percent are sponges occurring also in California. Of a collection from Lower California, nearly 1,000 kilometers south, 36 percent are species occurring also in California. From the Pacific coast of Panama, in contrast to the 62 percent and 36 percent, only 19 percent are species occurring also in California, and every one included in the 19 percent is a cosmopolitan species, not to be regarded as characteristic of any one locality. The Pacific coasts of Panama, judged from their sponge fauna, show not a trace of zoogeographical connection with those of North America but do show a little with those of Europe and with the polar regions and more yet with that small fraction of the West Indian fauna that occurs on the Caribbean coast of Panama, and finally contain a rather large proportion of species peculiar to the locality. How this compares with the west coast of South America remains to be seen.

DESCRIPTION OF PACIFIC COAST SPECIES

Genus APLYSILLA Schulze

APLYSILLA GLACIALIS (Merejkowsky)

This species is represented in the collection by U.S.N.M. no. 22211. It was found growing on wood in Balboa Harbor, beneath one of the piers. It is a thin encrustation, was rosy red in life, and is soft and fleshy; the conules are about 1 mm high and 2 to 4 mm apart. The eurypyllous flagellate chambers vary from 30μ by 60μ to 55μ by 105μ. The dendritic ascending fibers average about 50μ in diameter and arise from an extensive basal spongin plate.

The specimen is typical of the species, which was originally described from the Arctic as *Simplicella glacialis* by Merejkowsky (1878, p. 264) and later recorded from Australia by Lendenfeld (1889, p. 706). I (deLaubenfels, 1932, p. 125) recorded it from California, erroneously giving credit for the authorship to Dybowsky (1880, p. 65), in which reference it appears to be a new species, but actually it had been previously described. Thiele (1905, p. 489) recorded it from the sub-Antarctic, with the opinion that his specimen was conspecific with that of Lendenfeld but not with that from the Arctic. He therefore established a new name, *Aplysilla lendenfeldi*, for the specimens south of the Equator. There seems to be no good reason for the establishment of this new name, and it is here proposed that *glacialis* be retained for the entire species. The point was made that the Arctic specimen had fewer oscules than the others and that these had somewhat raised collars around them. This is almost certainly a reaction to the current, or a lack thereof, and has little if any taxonomic value. See Bidder (1923).

The Panama sponge now being described shows no evident oscules, probably as a result of abundant current near its location, and may be regarded as typical of the race that extends from the Arctic to the Antarctic.

Genus HALICLONA Grant

HALICLONA PERMOLLIS (Bowerbank)

This species is represented in the collection by U.S.N.M. no. 22200, found growing on the extensive rocky tide flats at Panama City. It is a thin crust, drab to violet, mediocre in consistency, and without any dermal specialization. The oscules, 2 to 3 mm in diameter, are surrounded by raised collars 3 mm high. The endosome is an isodictyal reticulation of oxeas 7μ by 130μ.

This cosmopolitan species has frequently been known under the specific name of *cinerea* (Grant), but Burton (1934) chooses as the lectotype of Grant's *Spongia cinerea* a specimen that is an *Adocia*. It therefore becomes necessary to apply Bowerbank's name of *permollis* to the species, which is a typical *Haliclona*. It is well characterized by its violet color, except where environmental factors interfere with it, perhaps by causing damage, in which instances a whole range of colors tending toward drab results. Bowerbank (1866, p. 278) founded the name as *Isodictya permollis*. I have transferred it to the genus *Haliclona* (de Laubenfels, 1936, p. 40).

HALICLONA COERULESCENS (Topsent)

This species is represented in the collection by U.S.N.M. no. 22240, from the Atlantic coast of Panama, and also (less typically) by nos. 22250, 22219, and 22208, from the Pacific coast. The Panamanian specimens are basically encrusting, but cylindrical or lamellate processes commonly grow up from the base. The color is typically blue in life, but where in some ways interfered with by the environment it tends toward drab. The consistency is mediocre, and the surface is comparatively even, with no special dermal skeleton at all. The pores are about 200μ in diameter and occur about two to the square millimeter. The oscules vary from 1 to 2 mm in diameter and occur very irregularly. The indications are that where the current passing the sponge is insufficient, the more evident oscules occur. The endosome is an isodictyal reticulation of oxeas varying from 5μ by 120μ commonly to 6μ by 150μ and rarely to 9μ by 175μ.

This species was described as *Reniera coerulescens* by Topsent (1918, p. 537) from the West Indies. It is here transferred to the genus *Haliclona*. The Panama specimens do not differ to any significant extent from Topsent's specimens. This is one of the most characteristic species of the Canal Zone. It was found growing intertidally on rocks near Panama City, on wood beneath the piers at

Balboa Harbor, and intertidally on rocks at Taboga Island, all on the Pacific side. On the Atlantic side it was found growing intertidally on the coast at Fort Randolph, and one macerated specimen was found cast on the beach at Fort Sherman. The distinctive blue color and the ease with which a lamellate form is assumed are perhaps its most characteristic features.

Genus ADOCIA Gray

ADOCIA CINEREA (Grant)

The specimens thus identified are represented in the collection by U.S.N.M. no. 22242, collected intertidally at Fort Randolph at the Atlantic end of the canal, and no. 22210, from one of the piers in Balboa Harbor at the Pacific end. The characteristic color in life appears to be a beautiful lavender, but as in the case of *Haliclona permollis* environmental factors may alter this in the direction of drab. The consistency is crisply friable. The endosome is smooth and is provided with a special reticulation of spicules, which, however, are just like those of the endosome. They make a beautiful isodictyal pattern, the apertures of which, about 300μ in diameter, are to be interpreted as pores, 500μ apart, center to center. The oscules, which are 2 to 3 mm in diameter, are usually on slightly raised processes, but curiously enough are not always terminally placed. The endosome is an isodictyal reticulation of oxeas about 10μ by 150μ to 13μ by 200μ.

This is not the cosmopolitan sponge frequently referred to in the literature as *Reniera cinerea*, but it bears a superficial resemblance to it and may or may not have been confused with it by earlier authors. Too little attention has been paid to the precise characters of the dermis of sponges. Reinvestigation of museum specimens and further collection may prove that *Adocia cinerea* is as nearly cosmopolitan as is *Haliclona permollis*, the species frequently referred to as *Reniera cinerea*. Both were originally described from European waters, the former as *Spongia cinerea* by Grant (1827, p. 204). It was transferred to *Adocia* by Burton (1934, p. 535).

Genus TOXADOCIA de Laubenfels

TOXADOCIA PROXIMA (Lundbeck)

This amorphous sponge is represented in the collection by U.S.N.M. no. 22222. It was collected intertidally on the rocks at Taboga Island near the Pacific entrance to the Panama Canal. In life it was a pretty violet and very soft. The surface is even. There is an isodictyal special dermal skeleton, not, however, containing any special sort of spicules, nor is it readily detachable. The pores are barely visible to the naked eye and occur about two to the square millimeter. The oscules are two in number, about 1.5 mm in diam-

eter, and have about them raised collars over 2 mm high. The endosome is an isodictyal reticulation of oxeas about 6μ by 140μ, among which occur toxiform microscleres 2μ by 80μ.

This specimen differs in no significant respect from that Arctic species described as *Gellius proximus* by Lundbeck (1902, p. 70). It is noteworthy that several of the species occurring near Panama City, less than 10° from the Equator, should have as their closest relatives Arctic or Antarctic species.

ZETEKISPONGIA, new genus

Diagnosis.—Family Phorbasidae. Structure more reticulate than plumose; special diactinal ectosomal spicules associated with special diactinal endosomal ones of another sort; arcuate chelas and sigmas for microscleres.

Genotype.—*Zetekispongia zonea*, new species.

The generic name is given in respect to the eminent zoologist, Dr. James Zetek, of the United States Department of Agriculture, Balboa, Canal Zone.

ZETEKISPONGIA ZONEA, new species

FIGURE 40

Holotype.—U.S.N.M. no. 22215.

The species is also represented in the collection by U.S.N.M. no. 22223. It was found abundant intertidally on the rocks of Taboga Island, near the Pacific entrance to the Panama Canal. The color in life was a characteristic reddish orange, which fades little in preservatives; this is quite unusual. The consistency is soft, slightly spongy. The surface is coarsely tuberculate, with lumps about 1 mm high and several millimeters wide, but otherwise comparatively smooth. There is a conspicuous detachable dermal specialization composed of tangentially arranged spicules and underlain by extensive subdermal cavities. The rare oscules are approximately 1 mm in diameter, very unevenly distributed, and apparently missing from some specimens, which is doubtless correlated with the fact that the sponge grows where the waves sweep back and forth, creating almost constant strong currents. The endosome bears some resemblance to bread in structure; it is much like many specimens of *Myxilla* and *Lissodendoryx*. There is some tendency to an isodictyal reticulation, which is obscured by the fact that each side of each mesh is composed of many instead of only one spicule. There are occasionally vague tracts, of several rows of spicules, reaching a diameter of approximately 80μ. The special dermal spicules are tylotes, 4μ by 200μ to 5μ by 170μ. The endosomal spicules are oxeas 9μ by 210μ to 11μ by 215μ. There are two sizes of arcuate isochelas for microscleres, but neither is typically arcuate. The larger type, approximately 36μ long, some-

times verges toward the palmate. The smaller one varies from 16μ to 24μ long and has three teeth at each end, which are so sharply pointed that this might almost be called unguiferate. There are abundant sigmas 16μ to 24μ in length of chord, and a few small oxeote spicules about 2μ by 150μ, which are only dubiously to be regarded as microscleres inasmuch as there exists a possibility that they may be immature stages of the principal megascleres.

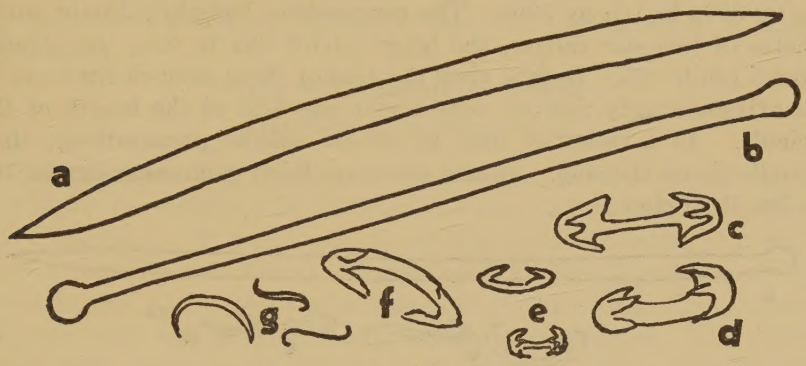

FIGURE 40.—*Zetekispongia zonea*, new genus and species: Spicules, ×666 (camera lucida). *a*, Endosomal oxea; *b*, ectosomal tylote; *c*, larger arcuate chela; *d*, abnormal form of same; *e*, side and front views of the smaller chela; *f*, side view of larger chela; *g*, three views of the sigmas.

Were the principal spicules monactinal instead of diactinal, this would be a *Lissodendoryx*. This one point of difference in the megascleres, however, is here interpreted as being exceedingly important. In sponges of the family Axinellidae, the transition from monactinal to diactinal spicules is made very readily, but this species is unlike those of the family Axinellidae; instead it should be regarded as of the family Phorbasidae.

Genus MYCALE Gray

MYCALE CECILIA, new species

FIGURE 41

Holotype.—U.S.N.M. no. 22207.

This species is exceedingly abundant on the rocks in the intertidal zone at Panama City but apparently is not found in any other location yet studied. At least during July and August 1933, it was easily recognized by its striking color scheme. In life it was basically green, abundantly provided with bright red specks, which are almost certainly embryos. They are about 200μ in diameter but show plainly to the unaided eye from a considerable distance. The consistency is soft, the surface even. The oscules are about 2 cm apart, and their maximum size cannot be readily given. They are discovered in sponges

exposed by the retreating tide only because of being at the center of stellate figures made by radiating subdermal canals; otherwise they would be overlooked. They are closed (perhaps by sphinctrate action) practically to zero diameter. In the endosome there are plumose ascending tracts ending at the surface in brushes of spicules. An approximate diameter of about 100μ might be assigned to them. There is only one type of megasclere, a tylostyle varying from about 7μ by 300μ to 10μ by 300μ. The microscleres include palmate anisochelas of two size ranges, the larger about 22μ to 25μ, the smaller about 12μ to 15μ. In face view the alae of these anisochelas seem to be extraordinarily narrow, only about one-fifth of the length of the spicule. As a result of this, in special spicule preparations, they usually lie on the side. Among them are fairly numerous sigmas 30μ in length of chord.

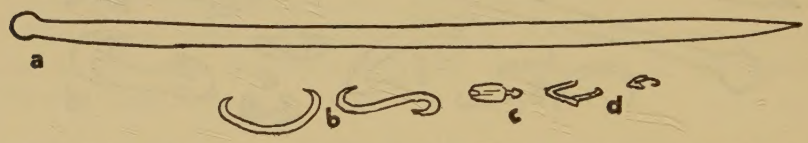

FIGURE 41.—*Mycale cecilia*, new species: Spicules, × 444 (camera lucida). *a*, Megasclere (tylostyle); *b*, two views of the sigmas; *c*, front view of the anisochela; *d*, side views of the chelas, showing extremes in size (there are intermediates).

The common West Indian *Mycale*, which is *M. angulosa* (Duchassaing and Michelotti, 1864, p. 89) has peculiarly narrow anisochelas, but its megascleres are exceedingly thin, only 1μ to 4μ in diameter, in contrast to 7μ to 10μ in the Panama sponge. Furthermore, *M. angulosa* is a sponge that quickly grows up coarse and erect with hollow cylindrical form predominating; it is cavernous and reddish brown. *Mycale imperfecta* Baer (1905, p. 20) from the east coast of Africa also has relatively narrow anisochelas, but these are of only one sort, and its megascleres are small, only about 3μ by 200μ, whereas its sigmas are large, frequently reaching nearly 80μ in chord length, and 3μ in thickness. Probably the closest relative to *cecilia* is *Mycale phyllophila* Hentschel (1911, p. 294). Its megascleres did not attain the thickness of those in *cecilia*. It is represented only by thin specimens growing on leaves. Were larger and maturer specimens available, further points of difference from the Panamanian sponge might be expected to appear.

Genus MICROCIONA Bowerbank

MICROCIONA ATROSANGUINEA Bowerbank

This species is represented in the collection by U.S.N.M. no. 22204. It occurs rather commonly on the rocks in the intertidal zone at Panama City as a bright-red, thin encrustation. Some of the smooth

dermal tylostyles are as small as 1μ by 100μ. Some of the endosomal tylostyles reach the maximum size of 20μ by 670μ and are minutely spined on their heads. The echinating acanthostyles are 9μ by 90μ, the toxas 120μ long, and the palmate isochelas 12μ to 15μ.

This, the genotype of *Microciona*, was described by Bowerbank (1862, p. 1109) from Great Britain, and his description of European specimens might do well for this from Central America. There is no significant point of difference, and the identification is made confidently.

Genus HALICHONDRIA Fleming

HALICHONDRIA PANICEA (Pallas)

This cosmopolitan sponge is represented in the collection by U.S.N.M. no. 22202 from the Pacific coast and by no. 22232 from the Caribbean. It was found encrusting rocks intertidally at both ends of the Panama Canal, on the beach at Fort Randolph on the Atlantic end, and on the Pacific side both on the mainland at Panama City and also on Taboga Island, 10 kilometers offshore. It is a thin crust, pale orange in life, friable in consistency, with a smooth surface, readily detachable special dermal membrane containing tangential spicules, which are, however, like those in the endosome, namely, sharply pointed oxeas of great variation in size. They range commonly from 3μ by 180μ to 11μ by 270μ and sometimes even to 16μ by 930μ.

It may conceivably be that there are different species of sponges in various parts of the world all of which by convergent evolution happen to share the same characteristics in common, and all identified as *Halichondria panicea*, but since it is impossible to separate them sharply on any characteristics that may be recorded on paper, it is customary to identify them all with the long-known European form first described as *Spongia panicea* by Pallas (1766, p. 388).

Genus PSEUDOSUBERITES Topsent

PSEUDOSUBERITES SULCATUS (Thiele)

This species, represented in the collection by U.S.N.M. no. 22214, was found growing on submerged wood near the piers in Balboa Harbor at the Pacific end of the Panama Canal. In life it was dull drab and semitransparent. The consistency is very soft; the surface is even, provided with a detachable special membrane over extensive subdermal cavities. This ectosome contains spicules tangentially placed. There are surface openings about 140μ in diameter, but these are not sharply differentiated into oscules and pores. In the endosome the spicules are arranged in considerable confusion. They are tylostyles ranging from 4μ by 160μ to 6μ by 275μ.

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This species was described as *Suberites sulcatus* by Thiele (1905, p. 417) from the extreme southern end of South America. Burton (1930, p. 334) also records it from the Antarctic and correctly transfers it to the genus *Pseudosuberites*. There is no considerable point of difference between the Panamanian specimen and those from the sub-Antarctic and Antarctic.

Genus LAXOSUBERITES Topsent

LAXOSUBERITES ZETEKI, new species

FIGURE 42

Holotype.—U.S.N.M. no. 22212, from Balboa, Canal Zone, on the Pacific coast; no. 22227 is a specimen from the Caribbean.

This is in some respects the species most characteristic of the Panama coast, being found abundantly at each end of the canal. The specimens are frequently large and massive, with digitate or hemispherical projections, often as much as or more than 8 cm high. The masses are frequently as large as a person's head. The color in life is fundamentally an ochre-yellow; an exceedingly thin layer at the surface, however, may be tinged with greenish or reddish color, or, as in the case of specimens from the Atlantic end of the canal, be almost completely covered with a brownish red. These colors may be due to the presence of algal cells on the surface. The consistency is weakly spongy or mediocre. The surface, aside from the above-mentioned digitate projections, is somewhat tuberculate but otherwise smooth and even, not at all hispid. The oscules are exceedingly contractile. In living specimens they can sometimes be made out, attaining a diameter of as much as 1 mm, but in preserved specimens they are often entirely or nearly invisible. A few exceptional individuals were found in which the oscules remained open, over 2 mm in diameter, and surrounded by a collar more than 2 mm high. These specimens grew where the currents were not very strong. This variation in oscular condition is a result of environmental stimuli and lacks taxonomical significance. The spicules in the ectosome are densely packed, erect, with points out, but do not differ significantly in size or shape from those in the endosome. The interior is minutely cavernous to dense, with occasional meandering canals about 2 mm in diameter. The flagellate chambers are subspherical, about 20μ to 25μ in diameter. About them the megascleres are strewn in confusion. No microscleres could be found, all the spicules being tylostyles varying from about 3μ to 20μ by at least 700μ in length, and how much more must remain problematical, inasmuch as the largest spicules were always found broken.

This species shows practically no trace of tendency to radiate form. Many specimens of *Laxosuberites* show a radiate form to a very slight extent but always under circumstances that lead to the suspicion that the radiate tendency had been present but then supressed by environmental conditions. *L. zeteki* grows frequently where other sponges assume the radiate form, and it is difficult to see how its placement could interfere with that result. In contrast to this, the other sponges

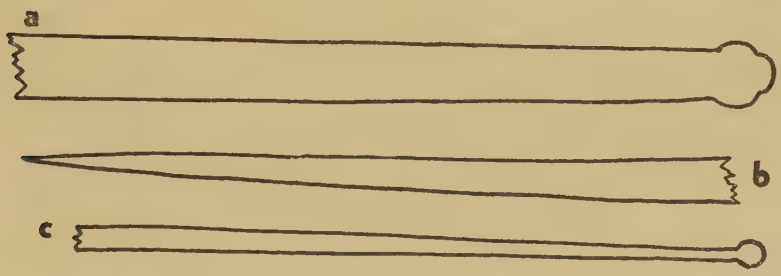

FIGURE 42.—*Laxosuberites zeteki*, new genus and species: Spicules, × 533 (camera lucida). *a*, Head or larger tylostyle; *b*, pointed end of same, middle portion not shown; *c*, head of smaller (immature) tylostyle.

in its immediate vicinity are practically never ramose. Its intertidal placement is not conducive to its habitus; instead the vigorous action of the waves would tend to compel most sponges to assume a merely encrusting form. In spite of this *zeteki* grows up massive with projections, occasionally almost ramose. For this reason there cannot be assigned any close relatives to it, and it is even questionable whether it should be left in the genus *Laxosuberites* or given another genus of its own. It is a very distinctively marked species.

The specific name is given in honor of Dr. James Zetek, of the United States Department of Agriculture, Balboa, Canal Zone.

Genus TETHYA Lamarck

TETHYA DIPLODERMA Schmidt

This subspherical sponge is represented in the collection by U.S.N.M. no. 22203. The color in life was yellow, the consistency cartilaginous. There is a cortex about 800μ thick grown into low tubercles about 500μ high and the same distance apart, apex to apex. It is hispid, with spicules projecting nearly a millimeter. The endosome is radiate, with ascending tracts of spicules about 200μ thick. The megascleres themselves are tylostyles, about 11μ by 900μ to 14μ by 1,200μ. The larger spherasters occur not at the immediate surface but in the deeper layer of the cortex, and rarely in the endosome, and are about 67μ in diameter. The smaller asters occur in the extreme outer cortex and abundantly throughout the

endosome. They are of two sorts, tylasters about 10μ in total diameter, and oxyspherasters only about 7μ in diameter.

This species was first described by Schmidt (1870, p. 52) from the West Indies and has since been recorded from the west coast of Mexico, the east coast of South America, both east and west coasts of Africa, the Indian Ocean, East Indies, and New Zealand. The Panamanian specimens are quite typical of the race as found around the world.

TABOGA, new genus

Diagnosis.—Family Tethyidae. The radiate, corticate structure resembles *Tethya*, but with very pronounced development of root structures. The strongyle-oxeote megascleres also resemble those of *Tethya*. The microscleres include spherasters somewhat like those of *Tethya*, but in addition there are typically three other distinct categories of asters, one of which is peculiar for sharply branched terminations to its rays.

Genotype.—*Taboga taboga*, new species.

TABOGA TABOGA, new species

FIGURE 43

Holotype.—U.S.N.M. no. 22216.

This species is moderately abundant intertidally on Taboga Island at the Pacific end of the entrance to the Panama Canal; it was not found elsewhere. The shape is subspherical, up to slightly over 2 cm in diameter, but most of the specimens are only about 1 cm in diameter. Each is attached to the substratum by ribbon-shaped roots, only 0.1 to 0.2 mm thick but usually 2 mm wide. There are ordinarily 5 to 15 such roots extending from each sponge and reaching out in some cases as much as 1 cm or more, anchoring the mass very firmly so that it may be held in place in spite of vigorous wave action. In life the surface is covered with a dull red layer 1 mm deep. This consists of a spicule plush of megascleres standing erect, rarely embedded in the white surface below them, and interspersed with rather loosely placed reddish cells that may or may not be proper to the sponge. The regularity with which they occur and the uniformity of their color suggest, however, that they are proper.

Below this red layer is a white layer of equal thickness. Its structure is corticate to cartilaginous. It represents the most extreme development of contractile tissue in any sponge known to me. Below the red-and-white layers the endosome is ochre-yellow and permeated by transparent fascicular columns packed with spicules radiating from the central point of the sponge to the surface. Above them the surface is thrown into tuberculous protrusions not quite 1 mm in

diameter. The oscules and pores are each minute and not readily made out. The root-like structures mentioned above are rendered shaggy, being densely packed with spicules, and contain practically no cavernous structures. The megascleres are spindle-shaped strongyles, or strongyloxeas, commonly 13μ by 600μ, occasionally slightly inequiended. Some, in fact, are almost styles. Spherasters with very sharply pointed rays, total diameter about 65μ, occur abundantly in the whitish ectosomal layer and to a certain extent also in the endosome. Both in the cortex and in the endosome occur also a few asters with conspicuously hastate pointed ends to the rays, total diameter 60μ, and comparatively abundant others, similar but

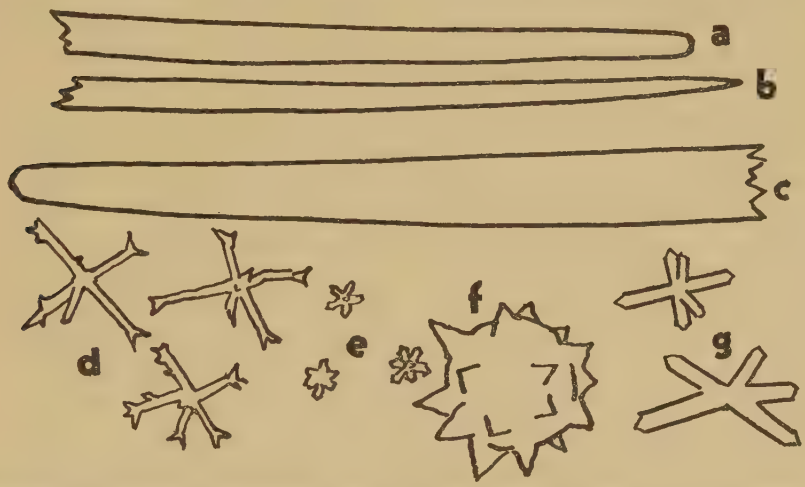

FIGURE 43.—*Taboga taboga*, new genus and species: Spicules, × 666 (camera lucida). *a*, Common termination (of end toward ectosome) of the megasclere; *b*, as above, but a less common sort; *c*, termination (away from ectosome) of the megasclere; *d*, three views of the most distinctive sort of aster; *e*, three views of the most common sort of aster; *f*, ectosomal spheraster; *g*, two views of the (uncommon) larger hastate rayed asters.

with very short rays, diameter 12μ. In the endosome occur only long-rayed euasters (perhaps provided with a minute centrum), total diameter 36μ to 60μ, the rays occasionally dichotomously or trichotomously branched at the end, and provided with a very few spines laterally placed on them.

One of the most remarkable characteristics of this unusual sponge is the strength of its muscular(?) tissue. When a living specimen is cut into deeply the cortex contracts so strongly that the endosome is forced to protrude from the wound. The collector with his fingers was unable to restrain this contraction and gives it as his opinion that the force was greater than that of the muscles that bend the fingers of a person with ordinary strength.

Genus PLACOSPONGIA Gray

PLACOSPONGIA INTERMEDIA Sollas

This species is represented in the collection by U.S.N.M. no. 22201, from the Pacific side, and no. 22233, from the Atlantic side of the Canal Zone. It is moderately common at each end of the canal, forming encrustations about 1 mm thick on coral or rock. The color in life is orange-ochre, changing to brown or drab in places where it seems to have been adversely affected by the environment. The consistency is friable, hard. The surface is given over to conspicuous polygonal plates separated by cracks only about 100μ wide. These plates are about 150μ to 350μ thick, and seem to be imperforate. The inhalent and exhalent apertures are presumably in the cracks between them. The endosomal structures are chiefly in confusion, but a few vague tracts about 100μ in diameter may be made out. The megascleres are exclusively tylostyles, of which, however, the heads are sometimes so small as to be barely larger than the shaft. These vary in size from about 6μ by 250μ to 8μ by 400μ. The dermal cortex is densely packed with sterrasters 20μ by 35μ to 35μ by 50μ. Among the other microscleres are small spheres about 8μ in diameter, covered by minute spines; these are young forms of the sterrasters, as shown by the existence of forms intermediate between them. These occur chiefly in the endosome, as do the abundant spirasters 1μ by 4μ to 2μ by 8μ. There are also short spirasters or plesiasters with very long spines with a tylote to strongylote modification at the end of each. These range from about 14μ by 18μ to 15μ by 20μ.

Placospongia intermedia was described by Sollas (1888, p. 272) from Punta Arenas, Central America. There is a large port by this name on the Pacific coast of Costa Rica, presumably the locality referred to. It appears to be a form characteristic of this portion of the world. There is no significant difference between the specimen found on the Pacific side of Panama and those found at the Atlantic side.

Genus GEODIA Lamarck

GEODIA GIBBEROSA Lamarck

This massive species is represented in the collection by U.S.N.M. no. 22217, from the Pacific side, and no. 22231, from the Atlantic side of Panama. It is gray-white, cartilaginous in consistency, and has a surface hispid in places only. The pores are very conspicuous, about 1 mm apart and 0.3 mm in diameter. The oscules are equally conspicuous, circular, in depressed areas, and are about 1 to 3 mm in diameter. There is a cortex 0.5 to 1 mm thick, which is densely packed with spherasters about 60μ by 75μ The endosome is strongly radiate with principally large oxeas, about 27μ by 800μ or larger, and plagio-

triaenes with rhabds about 30μ by 3,000μ. Among the microscleres, in addition to the sterrasters, there are euasters 10μ to 15μ in diameter and very small spherasters, mostly centrum, the entire spicule only about 3μ in diameter.

The last-mentioned type of microsclere is one of the most characteristic features of *Geodia gibberosa*, which was described by Lamarck (1815, p. 334) from the West Indian region, of which it is very characteristic.

Genus OSCARELLA Vosmaer

OSCARELLA LOBULARIS (Schmidt)

This species is represented in the collection by U.S.N.M. no. 22206. It was found growing (as usual) as a thin encrustation on rocks in the intertidal zone at Panama City on the Pacific side of the isthmus. In life it is transparent and drab, consistency mediocre, surface smooth and even. The oscules and pores were not optically evident. The flagellate chambers are spherical, 25μ in diameter.

This aspiculous, askeletal, interesting species is probably cosmopolitan, although nowhere abundant. It was first described as *Halisarca lobularis* by Schmidt (1862, p. 80). It is difficult to find any basis for separating those Oscarellas found in other parts of the world from the original European species with which they may indeed be genuinely conspecific. The Panama specimens are quite typical.

DESCRIPTION OF ATLANTIC COAST SPECIES

The six species found also at the Pacific end of the Panama Canal—*Haliclona coerulescens*, *Adocia cinerea*, *Halichondria panicea*, *Laxosuberites zeteki*, *Placospongia intermedia*, and *Geodia gibberosa*—are not repeated here.

Genus SPONGIA Linnaeus

SPONGIA BARBARA Duchassaing and Michelotti

This species is represented in the collection by U.S.N.M. no. 22230. It is a subspherical mass, black exteriorly and dull ochre in the endosome. The consistency is exceedingly spongy. The surface conules are not quite 1 mm high and about 1 mm apart. The oscules, about 3 mm in diameter, are raised, with slight collars about them. The flagellate chambers are spherical, about 20μ in diameter. The common fiber that makes up the customary dense reticulation is 30μ in diameter. The general structure is that of the common sponge of commerce, known as the "yellow."

Hyatt (1877, p. 515) records what he calls *Spongia lignea* from Pearl Island, Panama Bay. This is inadequately described because of the poor condition of Hyatt's material.

While in Panama I met an elderly Greek gentleman named Kefalos who claimed to have been a sponge fisherman in his younger days and to have collected and sold commercial sponges from the vicinity of Panama on both coasts, though more commonly from the Atlantic side. On the Pacific side I met a professional shark fisherman who claimed to have seen a few commercial sponges, although none could be found at that time. The evidence would appear to show that there was little economic importance to be attached to sponge fisheries from this immediate neighborhood, as commercial sponges do not exist in great enough abundance.

This species was collected on the coast at Fort Randolph on the Atlantic Coast of Panama near the north end of the Canal.

Genus TRYPESPONGIA de Laubenfels

TRYPESPONGIA COLUMBIA de Laubenfels

This species is represented in the collection by U.S.N.M. no. 22243. It was collected on the coast at the Atlantic side of the Canal Zone at Fort Randolph. In shape it is an amorphous mass. It was drab in life. Its consistency is exceedingly spongy. The surface conules are less than 1 mm high and are 1 mm apart, more or less. The abundant oscules are about 1 mm in diameter and are scattered in irregular groups. In the groups they are only 2 or 3 mm apart, but the groups themselves are 2 or 3 cm apart. The interior is strongly reticulate, with ascending fiber reaching 65μ in diameter, containing some foreign material in addition to the spongin. The more abundant secondary fibers are about 25μ in diameter and contain no foreign material. There is some detritus, especially broken foreign spicules, scattered loosely in the flesh. The histological structure of this species is very remarkable. The protoplasmic portions are arranged in thin sheets, only about 25μ to 35μ thick, which are arranged haphazard without any very definite pattern but crowded fairly close together. Those structures, which correspond obviously to flagellate chambers in ordinary sponges, are little more than apertures or oval holes through these sheets, 30μ to 40μ in diameter.

It is not known whether the species is important commercially. It was described from the West Indies by deLaubenfels (1936, p. 13).

Genus HIRCINIA Nardo

HIRCINIA CAMPANA (Lamarck)

This species is represented in the collection by U.S.N.M. no. 22248. It grows abundantly in shallow water near Fort Sherman at the Atlantic end of the Panama Canal. The typical shape is a vaselike form, frequently 20 cm high. The color in life is reddish brown, the consistency tough and spongy. It is coarsely conulose, with the conules 1 mm high and about 3 mm apart. The abundant oscules

are located chiefly or entirely on the interior of the vase. The principal spongin tracts are fascicular and coarse, and among them are many filaments of a substance resembling, but perhaps not the same as, spongin, about 4μ thick, with swollen heads 5μ or 6μ thick at each end, the total length being frequently more than 1 mm.

This species was described as *Spongia campana* by Lamarck (1814, p. 385) from the West Indies, where it is one of the most abundant and typical sponges.

HIRCINIA VARIABILIS (Schmidt)

This species is represented in the collection by U.S.N.M. no. 22249. It grows abundantly in shallow water near Fort Sherman at the Atlantic end of the Panama Canal. The shape is amorphous to encrusting, with digitate processes occasionally rising from the main mass. The color in life is greenish brown, and the consistency is tough and spongy. The conules are small, only about 0.5 mm high and 1 to 2 mm apart. The oscules are exceedingly conspicuous, not only because they have collars raised about them, but because the tissues immediately within them are very dark. The fascicular tracts and filaments are very much like those in the preceding species.

This may not be exactly the same species as that first described as *Filifera variabilis* by Schmidt (1862, p. 34), a Mediterranean form, but it does not seem appropriate to establish a new name for it at the present time. The form occurring at Panama is exceedingly abundant throughout the entire West Indian region.

Genus HALICLONA Grant

HALICLONA ERINA, new species

Holotype.—U.S.N.M. no. 22245.

This species was found growing intertidally on the Atlantic coast of Panama at Fort Randolph. The shape is amorphous to encrusting. The color in life was a brilliant green. The consistency is mediocre, with a notable lack of any special dermal skeleton, a lack entirely typical of the genus *Haliclona*. The endosome in places shows an isodictyal reticulation, and elsewhere there are vague ascending tracts about six spicule rows thick, or even as much as 50μ thick. The flagellate chambers are spherical, about 30μ in diameter. The only type of spicule present is a sharp-pointed oxea, but the variation in size is greater than is customary in the genus *Haliclona*, somewhat like that of *Halichondria*. The spicules range from as small as 3μ by 120μ to as large as 10μ by 200μ. Because of the surface structure, however, the identification is made with *Haliclona*, within which genus, in addition to various minute differences, the bright green

color is distinctive. It must be admitted that this may be a remarkable modification of some previously described *Haliclona*, due perhaps to unusual environmental conditions, but it is impossible to say which *Haliclona* has been so modified. It is not certain that this is the real situation, and it seems preferable to give a definite name by which the species may be referred to rather than merely to call it *Haliclona* "species indeterminate."

HALICLONA DORIA, new species

Holotype.—U.S.N.M. no. 22228.

One very large specimen was found growing in shallow water on the shores near Fort Randolph. It was a ramose bush, in life reaching a height of nearly 1 meter, with perhaps as many as 100 branches. Each of the branches is circular in cross section and a little over 1 cm in diameter. The color in life was mahogany-brown. The consistency in life was slightly flexible, very stiff. It is rather fragile as preserved in alcohol. To the naked eye the surface is even, although microscopically rough. The abundant pores are about 100μ to 200μ in diameter. The oscules are 2 to 3 mm in diameter and may or may not be provided with an oscular collar about them. They are very irregularly distributed, often in rows along one side only of a cylindrical branch. In the row they are only about 1 cm apart. The internal structures are very compact, the fibers crossing each other in reticulation almost at right angles, all of them, both ascending and transverse, being approximately the same size, varying between 20μ and 50μ. The ground substance about the fibers is subisodictyal. Only one type of spicule is present, an oxea 9μ by 170μ.

At and near the point of collection there were practically no other sponges even approaching the ramose form. It was a beach where the waves regularly broke with considerable force, and there was clear-cut evidence that the environment was not very favorable to this habitus. It is true that there was a depression in the immediate vicinity of this specimen, but not enough to have prevented all buffeting by waves. The conclusion, therefore, is that this species shows an unusually strong tendency toward the ramose form. This, together with the somewhat unusual color, is rather distinctive within *Haliclona*, large as that genus is. Perhaps the species nearest to the one under consideration is that described as *Thalysias subtriangularis* Duchassaing and Michelotti (1864, p. 85). Compared to that, *doria* has larger spicules, a different color, and the branches terminate in sharp points instead of blunt clublike shapes. This is about all that can be said definitely, but to the person who handles the two species in life, as I did, the general impressions and feeling are so strikingly different that there is no suggestion that the two are the same.

Genus STRONGYLOPHORA Dendy

STRONGYLOPHORA SANTA, new species

Holotype.—U.S.N.M. no. 22244.

This species is found growing intertidally on the shore near Fort Randolph. The shape is amorphous, the color in life greenish black, and the consistency between friable and stony. There is a distinct special dermal structure present, overlying extensive subdermal cavities. The surface is comparatively smooth and even. There are very few oscules, about 1 mm in diameter, not provided with collars about them. The internal structure is subisodictyal, somewhat resembling "crumb-of-bread." There is an astonishingly large variation in the size of the flagellate chambers. They are subspherical and range from only 18μ up to as much as 36μ in diameter. Throughout the basal reticulation there is another one of fibers containing much spongin and only a few rows of spicules, say three or four. This fiber is about 40μ in diameter. The spicules are of two sorts. The most abundant kind is a strongyle usually 17μ by 250μ, but varying from at least as small as 12μ by 240μ to as large as 18μ by 270μ. The second sort of spicule is an oxea 5μ by 215μ in ordinary size.

The genotype of the genus *Strongylophora* is *durissima*, described by Dendy (1905, p. 141) from Ceylon. It is much like the Panamanian sponge here described, except for paler color, crumpled external shape, and much smaller microxea, which were very thin and only 28μ long. The same general comparison may be made to all the other species customarily referred to the genus *Strongylophora;* i. e., their microscleres are a great deal smaller than those in *santa.* They are all probably rather closely related to one another.

Genus TEDANIA Gray

TEDANIA IGNIS (Duchassaing and Michelotti)

This species is represented in the collection by U.S.N.M. no. 22247. It grows abundantly in shallow water in the vicinity of Fort Sherman, the masses being frequently about the size of a man's fist. The color in life is a brilliant red. The consistency is mediocre to spongy. The surface is even, over low, wide tuberculate structures. There is a definite special dermal membrane overlying extensive subdermal cavities. The oscules are about 5 mm in diameter and frequently have oscular collars about them as much as 5 mm high or even more. The general structure is somewhat cavernous. The special dermal spicules are tylotes 4μ by 230μ. The endosomal spicules are styles 9μ by 300μ, and the microscleres are the so-called onychaetes, roughened rhapides, about 2μ by 110μ.

This species was first described as *Thalysias ignis* by Duchassaing and Michelotti (1864, p. 83). It is one of the most abundant and

characteristic of all West Indian sponges. As to whether it is conspecific with other species in the genus *Tedania* found in other parts of the world there is considerable room for argument.

FISHERISPONGIA, new genus

Diagnosis.—Family Ophlitaspongiidae. A genus with two distinct categories of megascleres, a dermal tylostyle and an endosomal plain style, associated with toxas and palmate isochelas. Diagnostic reference may or may not be added as to the quantity of sand present. The dense, almost radiate, structure, however, is not typical of the family Ophlitaspongiidae but verges strongly toward that of the order Haplosclerina. The genus that should be most closely compared here is *Camptisocale* Topsent (1927, p. 7) described from the Azores. It has significantly similar structure and has the polytylote dermal spicules over styles as principal megascleres. Its only microscleres, however, are odd-shaped palmate anisochelas. A second similar genus is

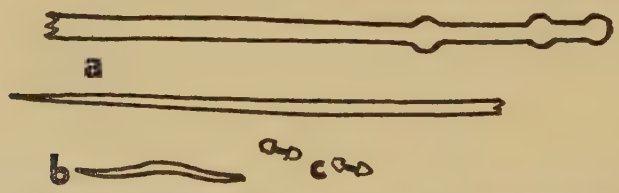

FIGURE 44.—*Fisherispongia ferrea*, new genus and species: Spicules, × 666 (camera lucida). *a*, Terminations of the megasclere sort (polytylote style) mid portion not shown; *b*, toxa; *c*, two views of the isochelas.

Phelloderma, described by Ridley and Dendy (1887, p. 85) from the South Atlantic. This also has the polytylote spicules together with plain styles, and palmate isochelas, but these are of remarkable shape, being almost the sort known as a placochela.

Genotype.—*Fisherispongia ferrea*, new species.

The generic name is given in respect to the eminent zoologist, Prof. W. K. Fisher, of Stanford University, California.

FISHERISPONGIA FERREA, new species

FIGURE 44

Holotype.—U.S.N.M. no. 22239.

This species is found growing intertidally at Fort Randolph. The shape is amorphous, and the color in life is bright red. The consistency is obscured by the fact that it is full of foreign materials and sand. The surface is between tuberculate and even, and the pores and oscules are not readily made out. There is a conspicuous layer of spicules with their heads on the substratum, standing erect with

respect to it, and from them semiplumose bushes of spicular tracts arise toward the surface, where they form tufts. The spicules at the surface are considerably smaller than those farther down and are polytylote tylostyles; i. e., they not only have the tylote swelling at the blunt end, but several similar swellings interposed here and there along the length of the spicule. Their size is about 2μ by 250μ. The endosomal spicules are smooth styles about 9μ by 500μ or 600μ. There are two sorts of microscleres, each very abundant. One sort is a toxa about 35μ long, and the other a palmate isochela only 10μ long.

Genus CLIONA Grant

CLIONA CARIBBOEA Carter

This species is represented in the collection by U.S.N.M. no. 22241. It occurs boring into calcareous material (frequently dead coral) on the beach at Fort Randolph and perhaps at other places in the Canal Zone. Its color in life is yellow, and the consistency is cartilaginous. The external structures are papillate bits of flesh that protrude here and there from the calcareous material and that reach a size of slightly over 1 mm in diameter and height. The apertures are slightly under 1 mm in diameter when fully opened, and they are found apically situated on the papilles. Only one type of spicule was found in the Panamanian specimens. This is a tylostyle about 14μ by 350μ.

This species was described by Carter (1882, p. 346) from the West Indies, of which it may be said to be very characteristic, unless it should be decided that it is conspecific with the cosmopolitan species *Cliona celata* Grant, to which it bears considerable resemblance.

Genus SPIRASTRELLA Schmidt

SPIRASTRELLA CUNCTATRIX Schmidt

The specimen thus tentatively identified is represented in this collection by U.S.N.M. no. 22226. It is a thin crust collected intertidally at Fort Randolph. It was bright orange in life and cartilaginous in consistency. The surface is even, and the spicules consist exclusively of tylostyles varying in size from 7μ by 250μ to 11μ by 415μ, associated with spirasters. These are at the most only 15μ by 20μ, and many are much smaller than this.

S. cunctatrix was described by Schmidt (1868, p. 17). The present specimen differs in many minor ways from the Mediterranean kind, but it is not now deemed advisable on the basis of the quantity of material present and in view of the slight differences, to establish for it a new species.

Genus TETHYA Lamarck

TETHYA AURANTIA (Pallas)

This species is represented in the collection by U.S.N.M. no. 22234. It occurs intertidally at Fort Randolph. It is spherical in shape and was bright orange-yellow in life. The consistency is cartilaginous, and the surface is coarsely tuberculate, with rounded tubercles crowded closely together, each about 2 mm in diameter and height. The megascleres are strongyloxeas about 25μ by 2500μ. The microscleres include large spherasters about 55μ in diameter and small spherasters only about 9μ in diameter.

This cosmopolitan species was described by Pallas (1766, p. 357) as *Alcyonium aurantium*. The Panamanian specimens do not differ in any significant respect from the numerous ones found in all parts of the world.

Genus CINACHYRA Sollas

CINACHYRA APION Uliczka

This species is represented in the collection by U.S.N.M. no. 22229. The one specimen was collected intertidally at Fort Randolph. It was yellow in life. Its consistency is between cartilaginous and mediocre. It is exceedingly hispid with a spicule plush 2 mm high or more over the entire surface. The abundant openings, representing probably both inhalent and exhalent structures, are cavities 1 to 3 mm in diameter, rounded at the bottom of the concavity, and so abundant that in many places they are only 3 mm apart. The internal structure is strongly radiate, including numerous oxeas, about 30μ by 3 mm long, and protriaenes and anatriaenes having rhabds of about the same size range as the oxeas. The clads of these spicules diverge very widely, almost at right angles to the main shaft, so that they do not differ greatly from orthotriaenes. The microscleres are small sigmoid spicules 10μ in length of chord.

This species was described by Uliczka (1929, p. 43) from the West Indies, to which locality it appears to be restricted.

PLAKOOSA, new genus

Diagnosis.—Family Halinidae. A genus having as spicules two size ranges of very small, much modified tetraxon spicules, the smaller of which resemble asters.

Relationship is indicated to *Plakortis* Schulze, which does not have the latter type of spicule, to *Halina* Bowerbank in which the second type is an obvious streptaster, and closest of all to a common West Indian sponge, *Roosa zyggompha* deLaubenfels (1934, p. 2), which has somewhat similar megascleres, but not the microscleres.

PLAKOOSA ELISA, new species

FIGURE 45

Holotype.—U.S.N.M. no. 22237.

The one specimen of this interesting species was collected intertidally at Fort Randolph. It is an encrustation considerably less than 1 mm thick and about 2 by 4 cm in lateral area. The color in life was blue; the consistency is mediocre. The surface is minutely punctiform. The depressions here referred to are perhaps to be interpreted as the location of pores. The entire surface is thickly set with apertures about 200μ in diameter, one or more to the square millimeter; which of these are exhalent and which inhalent cannot readily be made out. The internal structure is densely fleshy, except for the flagellate chambers, which are spherical, approximately 55μ in diameter. About them the spicules are densely crowded. Those that are possibly to be interpreted as megascleres are not much larger than microscleres. They are commonly siliceous triaxons, with each ray approximately 2μ by 25μ. Some of them

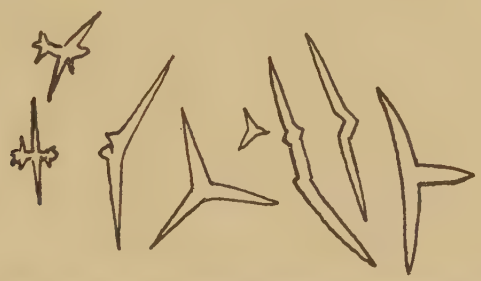

FIGURE 45.—*Plakoosa elisa*, new genus and species: Spicules, × 666 (camera lucida). Only relatively abundant sorts are shown.

may be described as sagittal with a very short rhabd or as a bent oxea with a spine at the middle. Others have two spines at the middle, as if they were reduced tetraxons. Still others are like oxeas, with a bend in the middle that doubtless represents the place where a hypothetical third or even fourth ray may have been placed. All the megascleres may plausibly be interpreted as reduced tetraxons. The microscleres bear a faint resemblance to asters, but although they show much variation in shape, the following type is common: There is an oxeote central shaft about 12μ long, from the middle of which protrude one or more branches about 4μ or 5μ long, each of which in turn has one or two branches only 1μ or 2μ long. Each ray is 1μ or less in diameter. These might be further named, by using the prefixes that are both applicable and customary, "micromesoorthotrichotriaenes."

Genus CHONDRILLA Schmidt

CHONDRILLA NUCULA Schmidt

This species is represented in the collection by U.S.N.M. no. 22235. It is found growing on the coast near Fort Randolph. The shape is amorphous to rounded, the color in life sepia-brown, and the consistency cartilaginous. The surface is even, and resembles rubber. The internal structures are densely colloidal, with fairly abundant spherical flagellate chambers about 20μ in diameter. The only type of spicule present is a spheraster about 30μ in diameter.

This species was described by Schmidt (1862, p. 39). It is found not only in the Mediterranean and in Australia, but abundantly in the West Indies.

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